Document No. FCF-PO-RPT-0006
Revision Initial Release

Fluids and Combustion Facility Document

Material Test Results for CIR Optics Bench

Date: September 9, 2003

Approved by John Reagan, FCF Project Material Approval, Quality Management Office, 8200

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Cleveland, OH 44135

Signature Page

(Official signatures on file with the FCF Project Control Specialist)

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Change Record

Rev.	Effective Date	Description
Initial Release	09/09/03	Initial Release

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1.0 INTRODUCTION

1.1 Purpose

The purpose of this document is to document the material testing results for the Fluids and Combustion Facility (FCF) Combustion Integrated Rack (CIR) Optics Bench, hereafter referred to as the Optics Bench. The material testing was performed to verify that the material properties of the as fabricated flight unit and Ground Integration Unit Optics Benches are consistent with the as published values for the material condition specified by the design, which is used for analysis purposes. The identified values of the tested material shall be used for the design allowables, as reported in FCF-PO-RPT-0009.

1.2 Scope

This document will outline the procedures as developed and performed for the material testing on a coupon taken from the same plate as the fabricated flight Optics Benches. These results are strictly limited to the Optics Bench flight hardware and are not applicable to any other hardware. The procedures include the requirements for specimen machining, heat treat temper conversion, Rockwell and Brinell hardness testing, Eddy Current testing, stress relief heat treatment, and tensile testing. The conclusive material testing results and acceptance are recorded and discussed in this document.

1.3 Background

Northrop Grumman drawing 67212MFDH20050 defines the design for the Optics Bench, which is machined from 7075 aluminum. The design calls for the final material condition of the aluminum to be T-7351 temper. Two Optics Benches were fabricated between 10/09/2002 and 04/11/2003, one (serial number 201) planned for the Flight Unit and one (serial number 202) planned for the Ground Integration Unit. Following fabrication of these items, a question was raised as to whether the fabrication processes that were followed really resulted in the required material condition or not. A piece of the original plate, from which the two Optics Benches were fabricated, was available. Therefore, it was decided to process a coupon as closely as possible to the actual benches and then test its material properties as verification of the as fabricated Optics Benches material condition.

2.0 REFERENCES

2.2 Reference Documents

Document Number	Document Title
ASTM-B557M-02A	Standard Test Methods for Tension Testing Wrought and Cast Aluminum-and Magnesium-Alloy Products {Metric}
ASTM-E10-01	Standard Test for Brinell Hardness of Metallic Materials
ASTM-E1004-02	Standard Practice for Determining Electrical Conductivity Using the Electromagnetic (Eddy-Current) Method
ASTM-E18-02	Standard Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
ASTM-E8-01	Standard Test Methods for Tension Testing of Metallic Materials
CIR-ECO-0114	Engineering Change Order for Flight Optics Benches

Document Number	Document Title
MIL-H-6088G	Heat Treatment of Aluminum Alloys
MIL-H-6088-G	Heat Treatment of Aluminum Alloys
MIL-HDBK-5J	Metallic Materials and Elements for Aerospace Vehicle Structures
MIL-STD-2154	Process for Inspection, Ultrasonic, Wrought Metals
SAE-AMS-2770G	Heat Treatment of Wrought Aluminum Ally Parts
FCF-PO-RPT-0009	Material Testing Summary and Design Allowables for CIR Optics Bench, Front End-Cap, Rear End-Cap and Interface Resource Ring

2.4 Acronyms

Acronym	Definition
CIR	Combustion Integrated Rack
FCF	Fluids and Combustion Facility
HDBK	Handbook
GRC	Glenn Research Center
KSI	Kilo pounds per Square Inch area
L	Longitudinal
LT	Long Transverse
MIL	Military
NASA	National Aeronautics and Space Administration
NGIT	Northrop Grumman Information Technology
ST	Short Transverse
TYS	Tensile Yield Strength
UTS	Ultimate Tensile Strength

2.5 Definition of Terms

Term	Definition
4D	Fourth Dimensional Elongation
HBW	Brinell Hardness Test Metric
HRB	Rockwell Hardness B-Scale Metric
IACS	Eddy Current, Electrical Conductivity Test Metric

3.0 MATERIAL TESTING

3.1 Initial Material

The initial material was an Aluminum 7075-T651 plate sized to 21 inches x 13 inches x 6 inches. Material certifications were provided from the optics bench fabrication vendor to certify the initial plate properties. The properties are as follows (See Appendix A.1 for complete Material Certification and A.2 for Temper Conversion Report):

T651 Long Transverse Direction, Initial Plate Properties	
Ultimate Tensile Strength (KSI), Max.	71.1
Ultimate Tensile Strength (KSI), Min.	69.5
Tensile Yield Strength (KSI), Max.	57.7
Tensile Yield Strength (KSI), Min.	55.5
Elongation (%), 4D Max.	9.9
Elongation (%), 4D Min.	9.9
T7351 Conversion Test Properties	
Rockwell hardness, B-Scale	79.0 – 81.0
Electrical Conductivity (Eddy Current)	40.0 – 40.5

3.2 Material Processing

The material processing procedures, as specified by the design of the Optics Bench can be found in CIR-ECO-0114. Certifications of the material processing procedures used for the as fabricated Optics Benches are provided in the Appendix A of this document. It is these procedures which were to be duplicated on the coupon to be tested.

3.3 Testing Specifications and Procedures

A test plan was provided to the material testing vendor. See Appendix B.4 for *Tensile Testing for Optics Bench – Sign Off Sheet*. The procedures for material testing are provided as follows:

1. The coupon to be tested arrived at Northrop Grumman Information Technology (NGIT), with the grain direction marked on the plate, as determined by the Optics Bench fabrication vendor.

2. The material testing vendor, Tensile Testing Metallurgical Laboratory, picked up the plate for delivery to their location.

3. Visual inspection of the plate was performed for any shipping damages. This included, but was not limited to, any chips, cracks, or visual alterations from the original form. There were no findings.

4. The coupon was sectioned in the long direction, resulting in two plates, equal in size, which were used for further testing. Each plate was 21 inches x 6.5 inches x 5 inches.

5. Processing began on the first plate, but it was discovered that a heat treating subcontractor did not follow the specified process, so it was set aside and returned to the Glenn Research Center (GRC). The second plate was then used and the processing was started on it from the beginning. The remaining steps and data are all with respect to this second plate.

6. Electrical Conductivity (Eddy Current) testing was performed per ASTM-E1004-02.

7. The plate was milled to a thickness of 4.5 inches ± .015 inches.

8. The plate was age hardened from Aluminum 7075-T651 to 7075-T7351. This temper conversion was performed per SAE-AMS-2770G specifications at 350 F ±10 F for a period of 12 hours. See Appendix B.5 for heat treatment certification.

9. Electrical Conductivity (Eddy Current) testing was performed per ASTM-E1004-02.

10. Brinell Hardness testing was performed per ASTM-E10-01.

11. GRC reviewed locations for specimens to be cut from this coupon with the material testing vendor and approved nine specimens total (Figure 1), three in each direction - Short-transverse (ST) , long-transverse (LT) , and longitudinal (L). The material testing vendor marked the plate for machining operation. Each of the material specimens was uniquely marked for further traceability, in accordance of material location (L1, L2, L3, LT1, LT2, LT3, ST1, ST2, ST3).

12. Nine specimens were machined in accordance with specifications for ASTM-E8-01. The LT and L direction specimens were machined to 0.505 size, while the ST specimens were machined to 0.356 size. See Figure 1 for location of specimens and markings.

13. All specimens were stress relieved at 300 F ±10 F for a period of three hours with an air-cooled quench. Thermal couples were included within furnace and a secondary thermal couple on center of plate.

14. Final machining and touch-up operations were performed on specimen threads.

15. All specimens were tensile tested according to ASTM-E8-01. External extensometers were utilized throughout the testing process.

16. The threaded segment for each specimen was sectioned and a Rockwell Hardness, B-Scale test was performed per ASTM-E18-02.

17. All results were recorded and placed in the Certified Test Report. See Appendix B for the official testing report from the material testing vendor.

18. All materials, specimens, and remnants were returned to GRC.

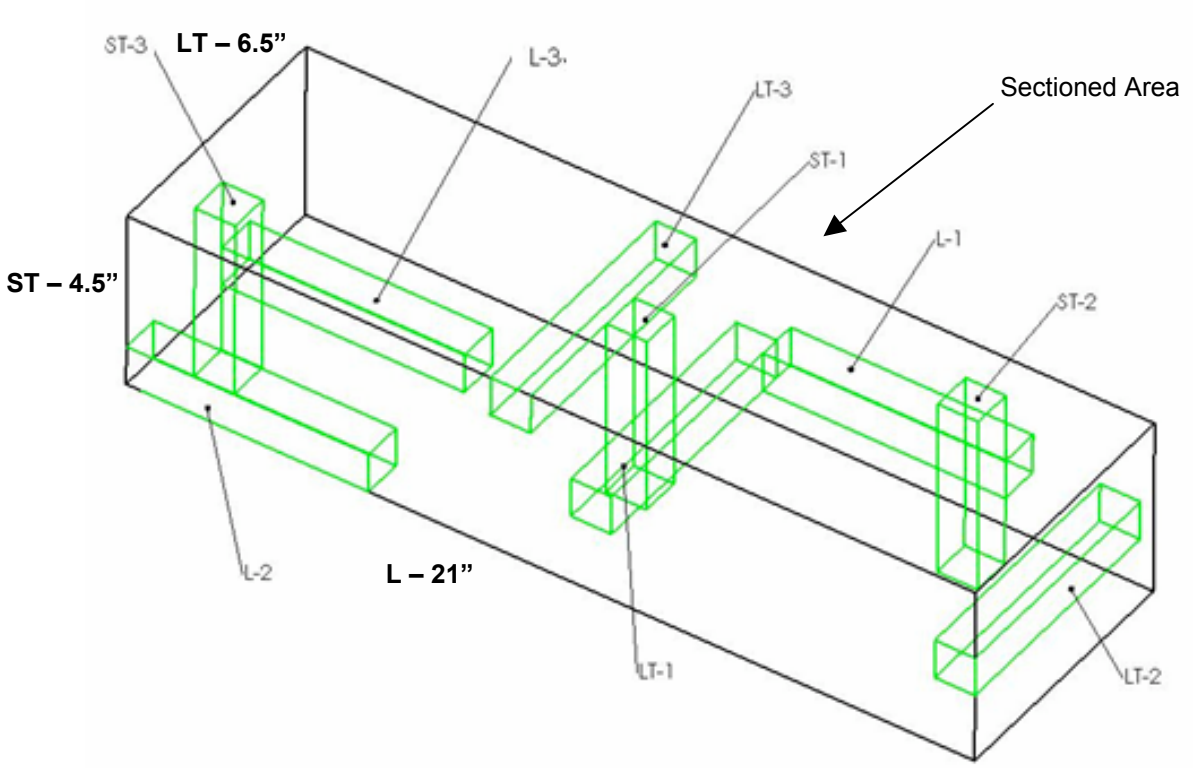


Figure 1 - Specimen Location on Optic Bench Test Plate

3.3.1 Material Testing Vendor

The material testing vendor providing all aspects of testing and data report is as follows:

Tensile Testing Metallurgical Laboratory
7815 Harvard Avenue
Cleveland, OH 44105
Tel: (216) 641 – 3290
Fax:(216) 641 – 1223

3.4 Material Test Data

The material test data can be found in Appendix B of this document. The material test data includes the Ultimate Tensile Strength (KSI), Tensile Yield Strength (KSI), Elongation (% in 4D), Brinell Hardness (HBW), Rockwell Hardness, B-Scale (HRB) and Conductivity (IACS). The following pages are included in Appendix B for the test:

1. Certified Test Report from Tensile Testing
2. Certified Heat Treatment Graphs
3. Tensile Test Graphing for Specimens
4. Material Processing Sign-Off Sheet
5. Certified Heat treatment, Temper Conversion Report

3.5 Material Results and Analysis

The tensile test results can be found in Table 1. This data is compared with the values from Table 3.7.6.0 of MIL-HDBK-5J. The material test results for the hardness and Conductivity testing can be found in Table 2. This data is compared with the values from Table IX of MIL-H-6088G.

Table 1 - Comparison of Tensile Test Results with MIL-HDBK-5J Properties for Strengths

	Material Test Specimen	Actual Material Test Result	Properties from MIL-HDBK-5J for 7075-T7351, 4 inch Plate
Longitudinal Direction			
Ultimate Tensile Strength (KSI)	L1	65.80	60
	L2	68.10	60
	L3	65.90	60
Average UTS (KSI)		*66.60*	60
Tensile Yield Strength (KSI)	L1	54.50	48
	L2	57.90	48
	L3	54.80	48
Average TYS (KSI)		*55.73*	48
Long-Transverse Direction			
Ultimate Tensile Strength (KSI)	LT1	63.70	61
	LT2	63.50	61
	LT3	68.20	61
Average UTS (KSI)		*65.13*	61
Tensile Yield Strength (KSI)	LT1	51.90	48
	LT2	51.70	48
	LT3	57.00	48
Average TYS (KSI)		*53.53*	48
Short-Transverse Direction			
Ultimate Tensile Strength (KSI)	ST1	61.80	57
	ST2	61.30	57
	ST3	63.90	57
Average UTS (KSI)		*62.33*	57
Tensile Yield Strength (KSI)	ST1	49.00	46
	ST2	48.80	46
	ST3	52.50	46
Average TYS (KSI)		*50.10*	46

Table 2 - Comparison of Tensile Test Results with MIL-HDBK-5J Properties for Elongation

	Material Test Specimen	Material Test Result	Properties from MIL-HDBK-5J for 7075-T7351, 4 inch Plate
Long-Transverse Direction			
Elongation (e, % in 4D)	LT1	9.00	6
	LT2	9.20	6
	LT3	9.40	6
Average e (% in 4D)		*9.20*	6

Table 3 - Comparison of Test Results with MIL-H-6088G

	Actual Material test Results	Properties from MIL-H-6088G for 7075-T73	Properties from MIL-H-6088G for 7075-T6
Conductivity before Heat Treatment (IACS)	32.0	-	30.5 - 36.0
Conductivity after Heat Treatment (IACS)	41.1	40.0 - 43.0	-
Brinell Hardness after Heat Treat (HBW)	130	125	135
Rockwell Hardness after stress Relief (HRB)			
L1	74	78	
L2	81	78	
L3	76	78	
LT1	76	78	
LT2	75	78	
LT3	80	78	
ST1	78	78	
ST2	74	78	
ST3	79	78	
Average Hardness	77	78	

4.0 CONCLUSIONS

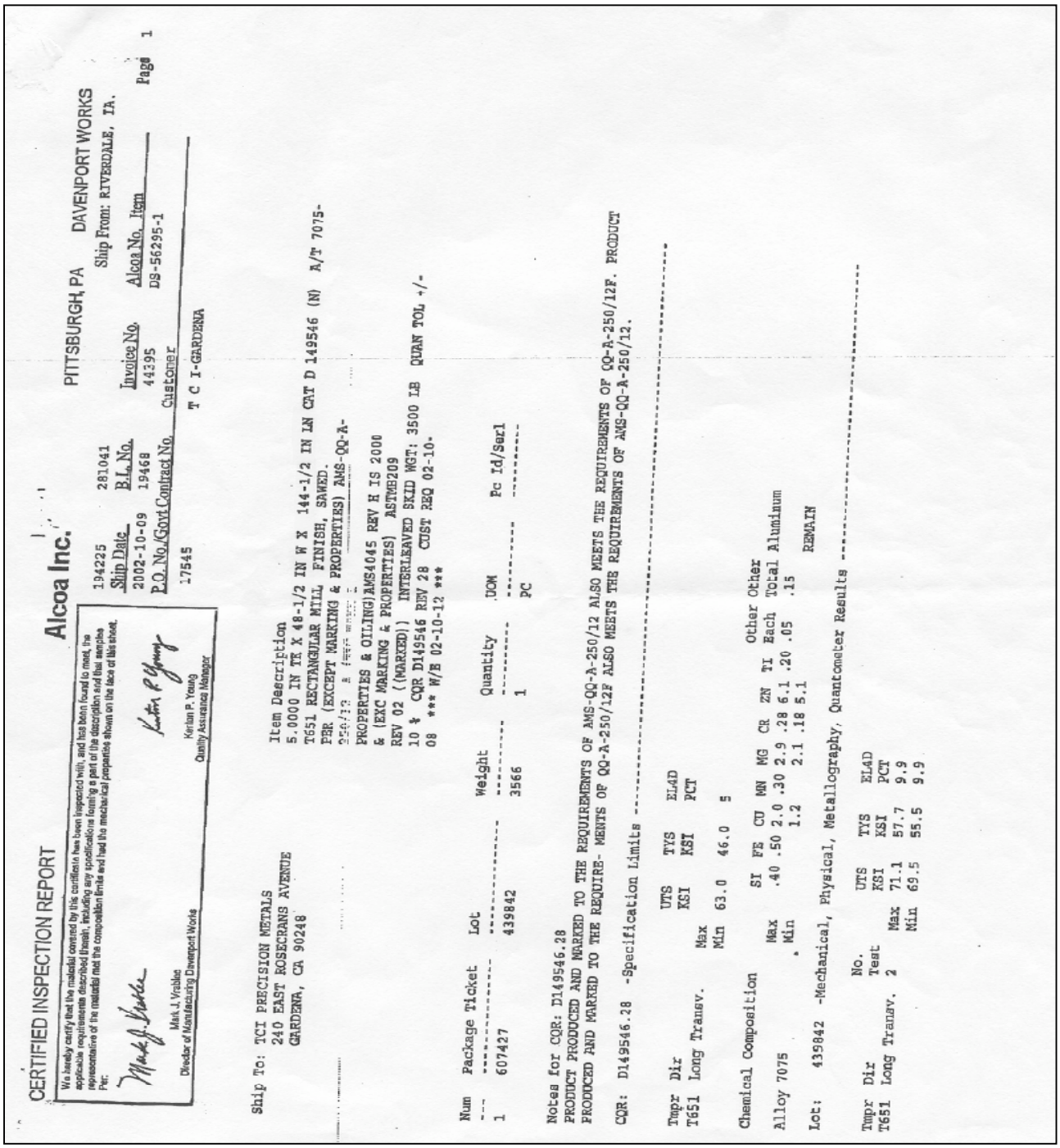
Based on these results, the material for the as built CIR Optics Benches (67212MFDH20050, serial numbers 201 and 202) can be inferred to be Aluminum 7075-T7351 Modified. The rationale behind this is as follows:

1. The as tested material was processed in the same manner as the as built Optics Benches. The heat treat temper conversions and stress reliefs as provided in the Appendices are identical for the as Built Optics Benchs and test material.

2. The material underwent the proper temper conversion according to the SAE-AMS-2770G Specification. Initial IACS test revealed 32.0 for conductivity, while the after heat treatment IACS revealed a conductivity of 41.1.
3. The Brinell and Rockwell hardness and conductivity properties after the 7075-T651 to 7075-T7351 conversion fall within the range of those stated in MIL-H-6088G.
4. The tensile properties are slightly above those for MIL-HDBK-5J, in comparison with an identical material for a 4 inch plate. Although, the as built Optics Bench was fabricated from 5 inch plate, the initial material properties have demonstrated that the material was above the standard strength requirements and specifications.
5. The stress relief slightly altered the final material properties, namely reducing hardness properties, thus the modification class.

APPENDIX A – INITIAL MATERIAL CERTIFICATION PACKAGE

A.1 Certified Inspection Report of Raw Material for Optics Bench



CERTIFIED INSPECTION REPORT

Alcoa Inc.

PITTSBURGH, PA DAVENPORT WORKS

Ship From: RIVERDALE, IA.

We hereby certify that the material covered by this certificate has been inspected with, and has been found to meet, the applicable requirements described therein, including any specifications forming a part of the description and that samples representative of the material met the composition limits and had the mechanical properties shown on the face of this sheet.

Per:

Mark J. Vrabec
Director of Manufacturing Davenport Works

Kerian P. Young
Quality Assurance Manager

194225	281041		
Ship Date	B.L. No.	Invoice No.	Alcoa No. Item
2002-10-09	19468	44395	DS-56295-1
P.O. No./Govt Contract No.		Customer	
17545		T C I-GARDENA	

Page 1

Ship To: TCI PRECISION METALS
240 EAST ROSECRANS AVENUE
GARDENA, CA 90248

Item Description
5.0000 IN TK X 48-1/2 IN W X 144-1/2 IN LN CAT D 149546 (N) A/T 7075-T651 RECTANGULAR MILL FINISH, SAWED.
PER (EXCEPT MARKING & PROPERTIES) AMS-QQ-A-[illegible]
PROPERTIES & OILING) AMS4045 REV H IS 2000
& (EXC MARKING & PROPERTIES) ASTME209
REV 02 (MARKED)) INTERLEAVED SKID WGT: 3500 LB QUAN TOL +/-
10 % CQR D149546 REV 28 COST REQ 02-10-08 *** W/B 02-10-12 ***

Num	Package Ticket	Lot	Weight	Quantity	UOM	Pc Id/Serl
1	607427	439842	3566	1	PC	

Notes for CQR: D149546.28
PRODUCT PRODUCED AND MARKED TO THE REQUIREMENTS OF AMS-QQ-A-250/12 ALSO MEETS THE REQUIREMENTS OF QQ-A-250/12F. PRODUCT PRODUCED AND MARKED TO THE REQUIRE- MENTS OF QQ-A-250/12F ALSO MEETS THE REQUIREMENTS OF AMS-QQ-A-250/12.

CQR: D149546.28 -Specification Limits ----------

Tmpr	Dir		UTS	TYS	EL4D
T651	Long Transv.	Max	KSI	KSI	PCT
		Min	63.0	46.0	E

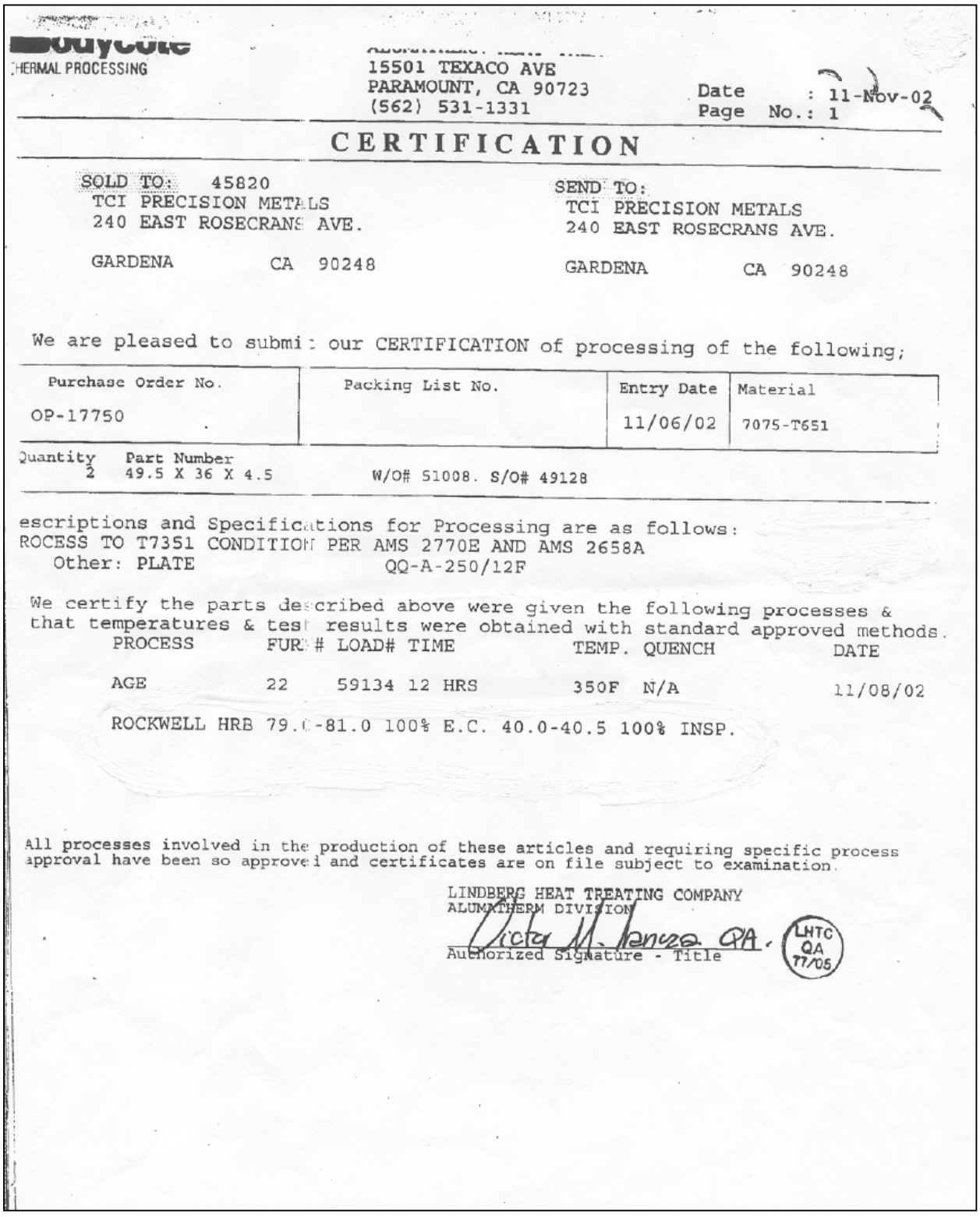
Chemical Composition

		SI	FE	CU	MN	MG	CR	ZN	TI	Each	Other Other Total Aluminum
Alloy 7075	Max	.40	.50	2.0	.30	2.9	.28	6.1	.20	.05	.15
	Min			1.2		2.1	.18	5.1			REMAIN

Lot: 439842 -Mechanical, Physical, Metallography, Quantometer Results ----------

Tmpr	Dir	No.	UTS	TYS	EL4D
T651	Long Transv.	Test	KSI	KSI	PCT
		2 Max	71.1	57.7	9.9
		Min	69.5	55.5	9.9

A.2 Certification of Temper Conversion of Optics Bench



HERMAL PROCESSING

15501 TEXACO AVE
PARAMOUNT, CA 90723
(562) 531-1331

Date : 11-Nov-02
Page No.: 1

CERTIFICATION

SOLD TO: 45820
TCI PRECISION METALS
240 EAST ROSECRANS AVE.

GARDENA CA 90248

SEND TO:
TCI PRECISION METALS
240 EAST ROSECRANS AVE.

GARDENA CA 90248

We are pleased to submi : our CERTIFICATION of processing of the following;

Purchase Order No.	Packing List No.	Entry Date	Material
OP-17750		11/06/02	7075-T651

Quantity Part Number
2 49.5 X 36 X 4.5 W/O# 51008. S/O# 49128

escriptions and Specifications for Processing are as follows:
ROCESS TO T7351 CONDITION PER AMS 2770E AND AMS 2658A
Other: PLATE QQ-A-250/12F

We certify the parts described above were given the following processes & that temperatures & test results were obtained with standard approved methods.

PROCESS	FUR #	LOAD#	TIME	TEMP.	QUENCH	DATE
AGE	22	59134	12 HRS	350F	N/A	11/08/02

ROCKWELL HRB 79.0-81.0 100% E.C. 40.0-40.5 100% INSP.

All processes involved in the production of these articles and requiring specific process approval have been so approved and certificates are on file subject to examination.

LINDBERG HEAT TREATING COMPANY
ALUMATHERM DIVISION
Victor M. Ramos QA.
Authorized Signature - Title

LHTC QA 77/05

A.3 Stress Relief Heat Treatment Certification

Bodycote
THERMAL PROCESSING

ALUMATHERM HEAT TREAT CO
15501 TEXACO AVE
PARAMOUNT, CA 90723
(562) 531-1331

Order No.: 259446
Date : 14-Mar-03
Page No.: 1

CERTIFICATION

SOLD TO: 45820
TCI PRECISION METALS
240 EAST ROSECRANS AVE.
GARDENA CA 90248

SEND TO:
TCI PRECISION METALS
240 EAST ROSECRANS AVE.
GARDENA CA 90248

We are pleased to submit our CERTIFICATION of processing of the following;

Purchase Order No.	Packing List No.	Entry Date	Material
OP-17750		12/20/02	7075-T7351

Quantity 2 Part Number 49 X 35.5 X 4.25
WO# 51008, S/O# 49128

Descriptions and Specifications for Processing are as follows:
STRESS RELIEVE PER SHOP PRACTICE.
Other: BARE. QQ-A-250/12F

We certify the parts described above were given the following processes & that temperatures & test results were obtained with standard approved methods.

PROCESS	FURN#	LOAD#	TIME	TEMP.	QUENCH	DATE
STRESS REL	6	60024	3 HRS	300F	A/C.	12/21/02

DUPLICATED CERTIFICATION.

All processes involved in the production of these articles and requiring specific process approval have been so approved and certificates are on file subject to examination.

LINDBERG HEAT TREATING COMPANY
ALUMATHERM DIVISION

Victor M. Tamara QA
Authorized Signature - Title

LHTC QA 7/7/05

A.4 Shop Practice for Stress Relief Heat Treatment

The 'best shop practice' stress relief consists of applying heat to a part with the theory that heat has been demonstrated to relieve stress in aluminum parts. The temperature applied should be 50F degrees below the artificial aging temperature. Staying 50F degrees below the artificial aging temperature prevents the part mechanical properties from being altered. For example, 7075-T7351 condition begins to have its mechanical, Rockwell hardness and electrical conductivity properties altered at between 320F to 350F degrees or above. By staying at 300F, such properties are proven to remain unaltered after the heat application. The amount of soak time at the stress relief temperature is based upon historical industry practice where 3 to 5 hours worth of soaking was discovered to be effective in relieving stresses so that the machine shops subsequently experienced no movement of the parts during final machining. This concludes our explanation of stress relieving per 'best shop practice'. Regards.

APPENDIX B – OFFICIAL TEST REPORT

B.1 Certified Test Report from Tensile Testing

TENSILE TESTING
METALLURGICAL LABORATORY

A DIVISION OF J.T. ADAMS CO., INC.
7815 HARVARD AVE.
CLEVELAND, OHIO 44105
PHONE (216) 641-3290
FAX (216) 641-1223
www.tensile.com

CERTIFIED TEST REPORT

NASA-Glenn Research Center
21000 Brookpark Road
Cleveland OH 44135

Job No.: A3-164-374*
Date: 7-3-03
Cust. PO#: Verbal-PRG

Description: 9 samples 21" x 13" x 5" Tag# 17526
Material: 7075 T651
Spec: SAE-AMS-2770G

TEST RESULTS

	Tensile, ksi	Yield, .2% ksi	Elong., % in 4D	Hardness, HRB
L-1	65.8	54.5	11.3	74
2	68.1	57.9	13.0	81
3	65.9	54.8	11.0	76
LT-1	63.7	51.9	9.0	76
2	63.5	51.7	9.2	75
3	68.2	57.0	9.4	80
ST-1	61.8	49.0	6.3	78
2	61.3	48.8	6.1	74
3	63.9	52.5	6.6	79

Test Method: ASTM E8-01

Conductivity After Heat Treat (ASTM E1004-02)

41.1% IACS

Hardness Test After Heat Treat (ASTM E10-00a)

130 HBW_{500kgf}

Heat Treatment

*Age hardened @ 350°F for 12 hours ± 10°F

Stress Relieved @ 300°F for 3 hours, Air Cooled

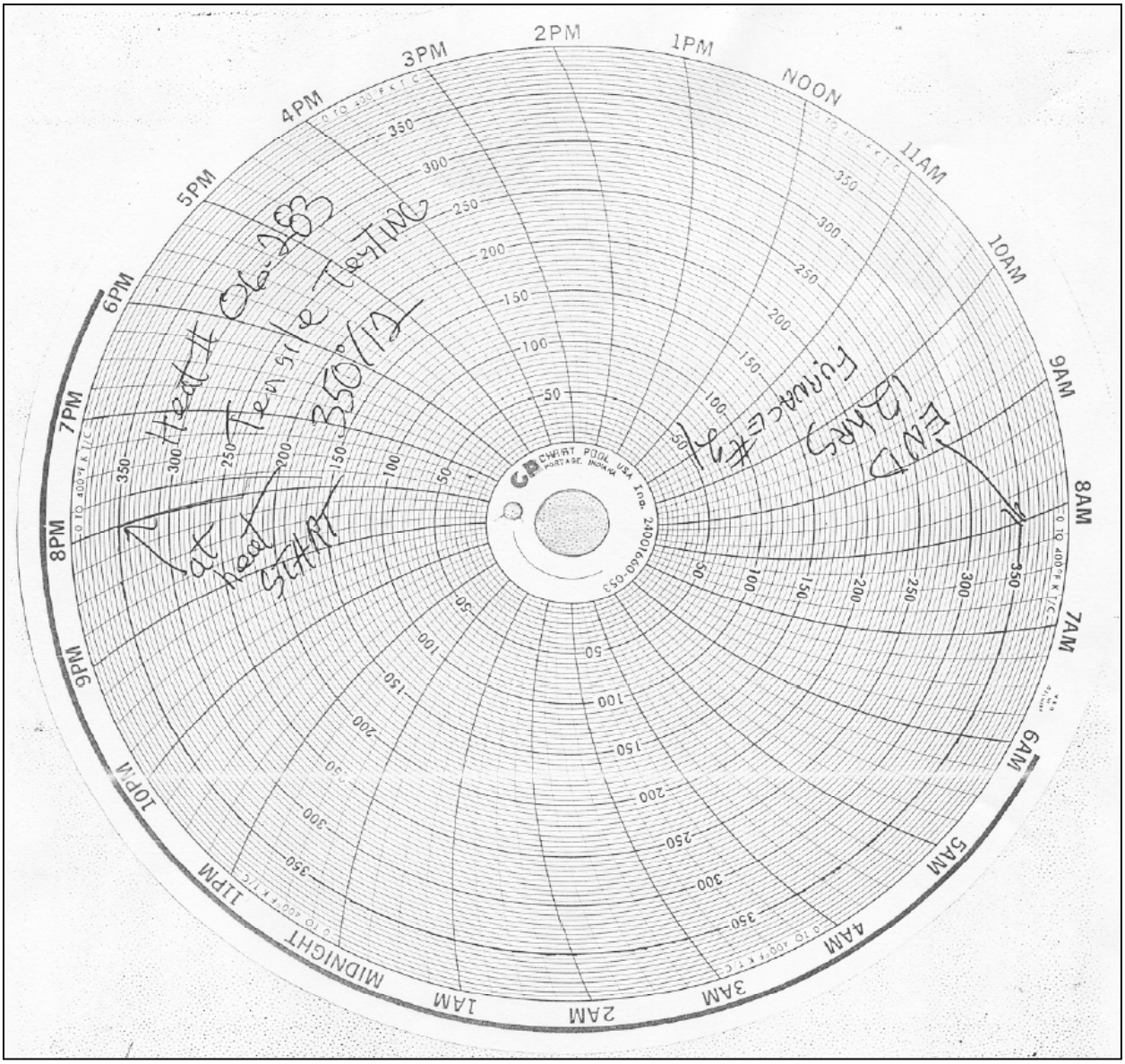
JA Bartholomew
Authorized Agent

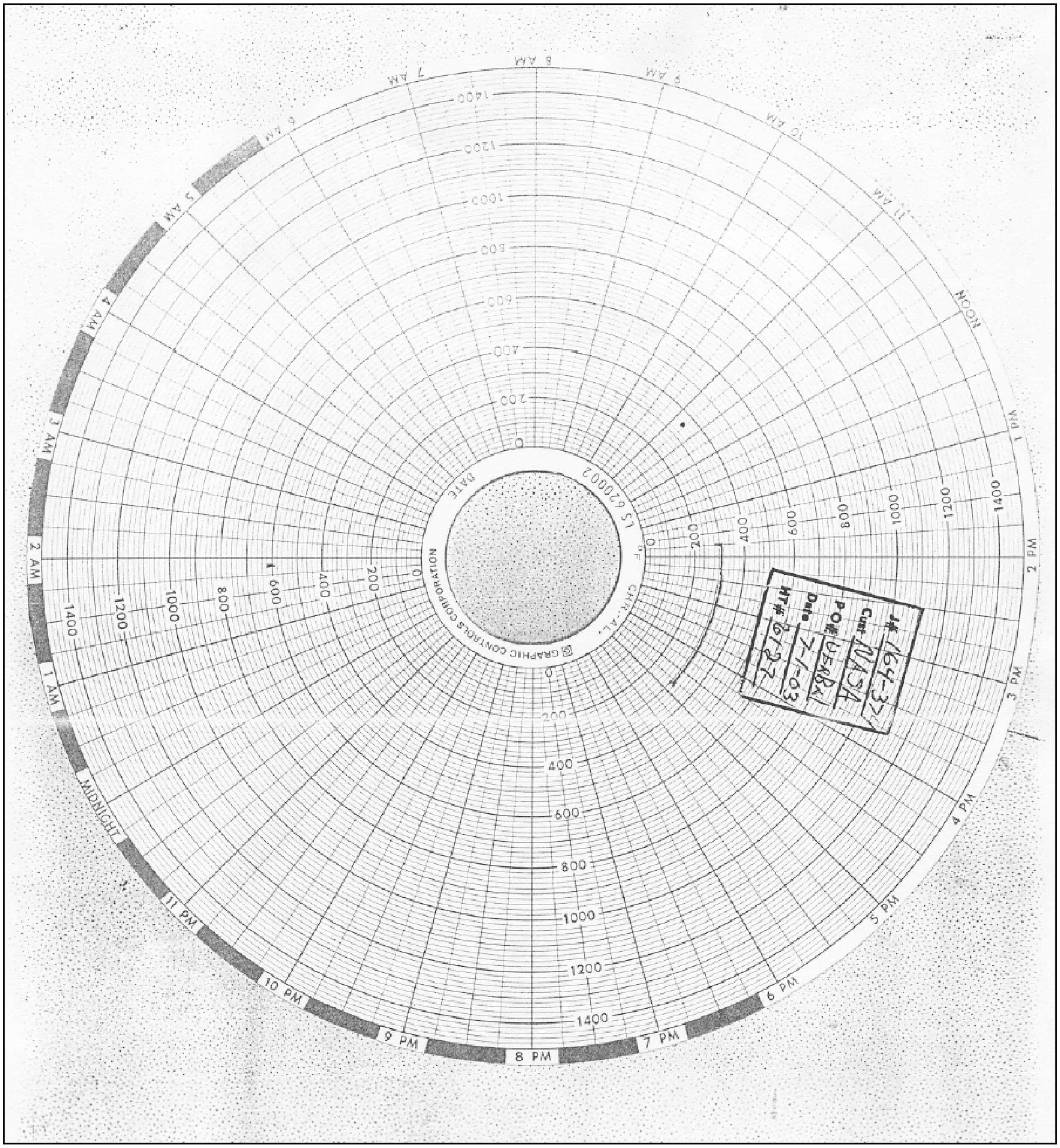
* The above testing was performed by a Tensile Testing Metallurgical Laboratory approved supplier.

ACCREDITED
Cert No. 0161

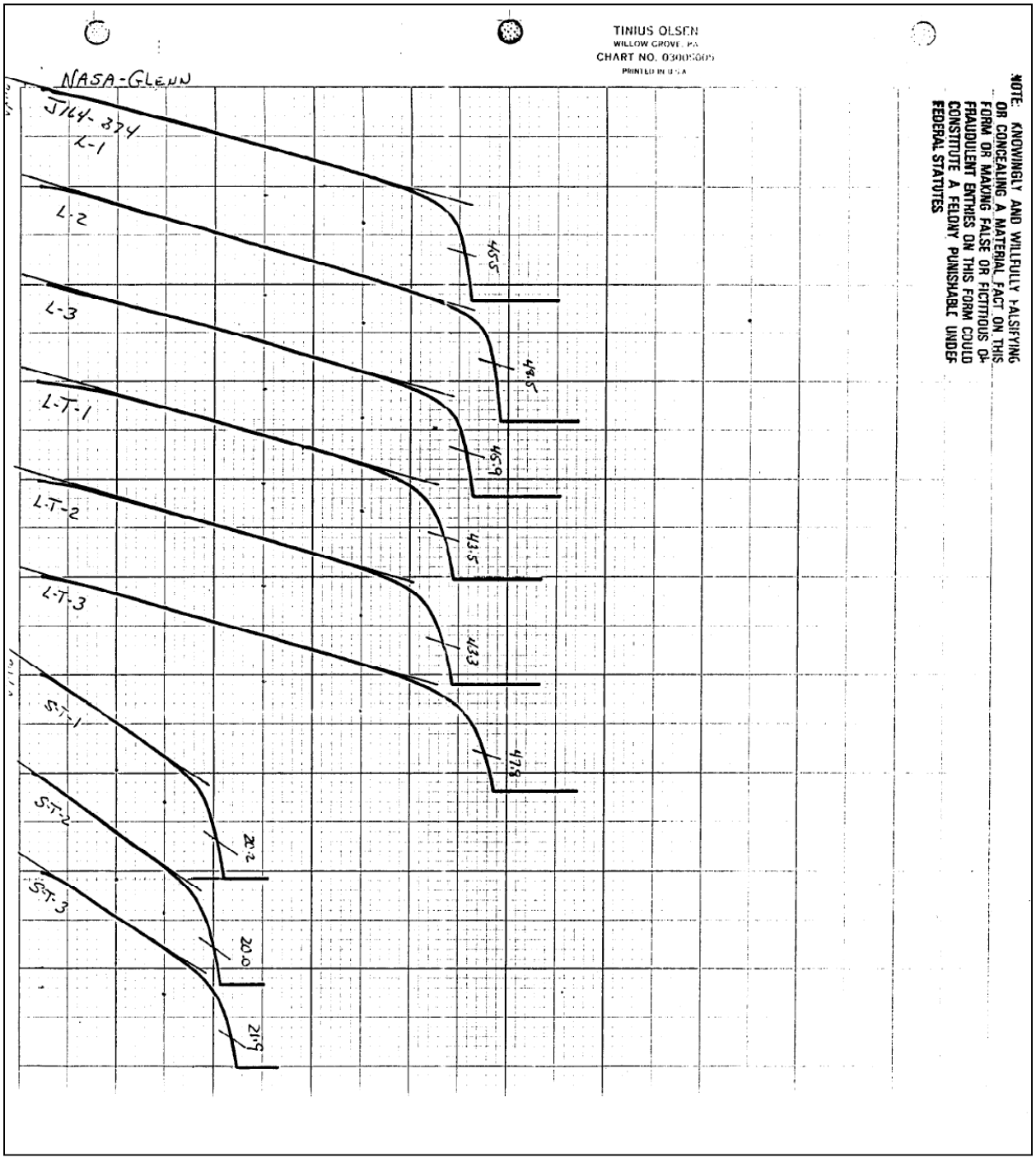
Page 1 of 1

B.2 Certified Heat Treatment Graphs




8 AM
9 AM
10 AM
11 AM
NOON
1 PM
2 PM
3 PM
4 PM
5 PM
6 PM
7 PM
8 PM
9 PM
10 PM
11 PM
MIDNIGHT
1 AM
2 AM
3 AM
4 AM
5 AM
6 AM
7 AM
0
200
400
600
800
1000
1200
1400
DATE
°F
GRAPHIC CONTROLS CORPORATION
J# 164-37
Cust NASA
PO# UE6BA
Date 7-1-03
HT# 6727

B.3 Tensile Test Graphing for Specimens



B.4 Material Processing Sign-Off Sheet (Tensile testing for Optics Bench – Sign-off Sheet)

Tensile Testing for Optics Bench – Sign Off Sheet

Procedures	Initial
1. Pick up Plate at Northrop Grumman.	WWB 6/12/03
2. Visual inspection of plate (7075-T651) for any shipping damage. Original plate size 21 in x 13 in x 5 in.	TTML 15 6/13/03
3. Section material in half the long direction so there will be two (2) plates each 21 in x 6.5 in x 5 in, in length. Save plate that will not be used.	TTML 9 6-13-03
4. Mill one plate to 4.50 ± .015 in thickness.	TTML 2
5. Heat treat this plate from 7075-T651 => 7075-T7351 per SAE-AMS-2770G. Shall be treated for 12 hrs @ 350F ± 10F. This shall be done in accordance with original certification and specification. Provide Certification from vendor (sub-contractor).	HTG
6. Conduct Electrical Conductivity testing according to ASTM ~~B193~~ 1004-02 and MIL-STD-1537C. Record results in final report.	TTML 11 6-26-03
7. Cut and machine 9 specimen coupons from heat treated plate, 3 in each direction (L, T and S) per NASA direction. NASA will approve coupons before final cut.	TTML 9 6-27-03
8. Conduct Brinell hardness test according to appropriate ASTM testing procedure. Record results and incorporate in final report.	TTML 27
9. Specimens shall be machined in accordance with suggested configuration and dimensions referenced in ASTM E8 (.505 preferred or otherwise directed). Each specimen shall be uniquely marked. Mark all remnant material and grain direction that has not been machined and save.	TTML 19 6-30-03
10. All specimens shall be heat treated (stress relieved) for 3 hrs @300F ± 10F, Quench – Air Cooled according to certification and shop practice provided. Provide Certification. Include secondary thermal couple in center of load.	TTML 2 HTG 6/27 7-1-03
11. Final machining and clean-up operations on specimens.	TTML 2
12. Specimens shall be tensile tested according to ASTM E8. Use of external extensometers shall be utilized when available. Save all specimen pieces.	TTML 7
13. Conduct Rockwell B-scale hardness test on each sample cut from specimens. Record results and include in final test report.	TTML 7
14. Record results shall include specimen mark (grain direction and sector). Results shall be recorded as in ASTM E8. Provide all plots and identification on each plot.	TTML 7

15. Provide final test report, all test specimens, remnants and sign off:

Jeffrey D. Smith TTML 15 — Quality Assurance

Paul R. Gradl 7/11/03 — Paul R Gradl

B.5 Certified Heat Treatment, Temper Conversion Report

HI TECMETAL GROUP

HTG/METALLURGICAL
28910 Lakeland Blvd.
Wickliffe, Ohio 44092
Phone (440) 943-4555

CERTIFIED TEST REPORT **DATE: 6/25/03**

CUSTOMER NAME	: TENSILE TESTING
PURCHASE ORDER	: JA3164-374
CUSTOMER PART #	: TENSI-T651
PART NAME	: BAR
MATERIAL TYPE	: ALUMINUM
QUANTITY ON P.O.	: 1 PC / 62 LBS.
AMOUNT SHIPPED	: 1 PC / 62 LBS.
CONTAINERS	: 1 SKID
BATCH NUMBER #	: N/A
HEAT TREATER	: MODERN STEEL TREATING
SHOP ORDER NO	: 397792-00
PCS CHECKED	: 1 PC

LAB NUMBER : N/A
SPECIFICATION : SAE-AMS-2770G

AGE HARDEN

PARTS RUN AT 350°F FOR 12 HOURS +/-10 DEGREES F.

QUALITY STATEMENT:

THESE PARTS ARE ACCEPTABLE TO THE SPECIFICATION
I do certify under the penalty of perjury that the above test results are a true copy of the data from the tests performed

Metallurgical Laboratory

MATERIALS LAB: R.L.Ward,PE, Director of Quality and Engineering. Jewell Hawkins, Materials Lab Supervisor.